

## REMARKS

Applicants respectfully request reconsideration of the present application in view of the foregoing amendments and in view of the reasons that follow. Applicants respectfully request that the foregoing amendments be entered at least because they raise no new issues requiring further search or consideration.

Claim 4 is requested to be cancelled without prejudice or disclaimer.

Claims 1, 7, 10 and 17 are currently being amended.

This amendment deletes and changes claims in this application. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claim(s) remain under examination in the application, is presented, with an appropriate defined status identifier.

After amending the claims as set forth above, claims 1, 3, 5-10, 12, 14-18 and 20-25 are now pending in this application.

### **Rejections under 35 U.S.C. § 103**

Claims 1, 3-10, 12, 14-18 and 20-23 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,693,203 to Ohhashi et al. (hereafter "Ohhashi") in view of applicants' alleged admission in the Rule 132 declaration filed on April 12, 2004. Claims 24-25 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Ohhashi in view of acknowledged prior art on page 2, lines 1-24 (hereafter "the APA"). Applicants respectfully traverse these rejections for at least the following reasons.

#### ***Claims 1 and 18***

Claims 1 and 18 are each directed to a high purity Nb sputtering target. Claim 1 recites an amount of Ta less than 3000 ppm, a Ta content dispersion within 30%, and an amount of oxygen less than 200 ppm, while claim 18 recites an amount of oxygen less than 200 ppm and an oxygen content dispersion within 80%. Ohhashi fails to suggest a Nb sputtering target with the Ta amount, Ta dispersion, or oxygen amount of claim 1, the oxygen

amount or dispersion of claim 18, or the advantages of such a sputtering target in forming an interconnection film with low resistivity.

Ohhashi discloses a sputtering target. The sputtering target is of a material selected from the group of W, Mo, Ti, Ta, Zr and Nb, the target having uniform microstructure with crystal grain sizes of no more than 350  $\mu\text{m}$  (col. 6, lines 32-43). In particular, Ohhashi discloses examples of a high purity W sputtering target (example 5) and a high purity Ti sputtering target (example 6).

Ohhashi, however, fails to suggest a Nb sputtering target with a Ta and oxygen amount and Ta content dispersion as recited in claim 1, or oxygen amount and content dispersion as recited in claim 18. While it is entirely possible that the Nb sputtering target of Ohhashi would contain inevitable impurities such as Ta and oxygen, Ohhashi recognizes neither the importance of reducing the Ta and oxygen impurities to the level recited in claims 1 and 18, nor the recited dispersion levels of these claims.

***The claimed dispersion is not inherent in Ohhashi***

The recited dispersion levels of Ta and oxygen recited in claims 1 and 18 are not inherent in Ohhashi. The Office Action suggests that the dispersion % of Ta and oxygen impurities in the Nb sputtering target of Ohhashi must be zero, stating on page 3:

Since Ta and O are inevitable impurities, their dispersion would be uniform in Nb sputtering target. Thus, the dispersion % of said O and Ta is zero.

Applicants respectfully disagree that merely because Ta and oxygen may be inevitable impurities, they would have a 0 dispersion % or a dispersion % in the range recited in the claims.

For the convenience of the Examiner, applicants provide below a discussion of dispersion % illustrating that a 0 dispersion % of Ta impurities is not inherent in a Nb sputtering target. Table A below illustrates the measured Ta content and dispersion for Nb sputtering targets No. 3 and No. 4 of Table 1 of the present application. The Appendix illustrates the positions of the Nb targets where the Ta content was measured.

**TABLE A** Ta in targets 3 and 4

|   | No. 3                              |  | No. 4                               |  |
|---|------------------------------------|--|-------------------------------------|--|
| Max (ppm)   | 1830                               |  | 2540                                |  |
| Min (ppm)   | 784                                |  | 2298                                |  |
| Dispersion  | 40%                                |  | 5%                                  |  |
| Longitudinal (ppm)  | 1261, 1518,<br>1830<br>1160, 925   |  | 2308, 2510<br>2540<br>2415, 2362    |  |
| Horizontal (ppm)  | 1050, 1442,<br>(1830)<br>1025, 784 |  | 2298, 2470,<br>(2540)<br>2390, 2355 |  |
| Average (ppm)   | 1222                               |  | 2404                                |  |
| Resistivity of<br>interconnection film<br>( $\mu\Omega$ cm) | 3.9                                |  | 3.8                                 |  |

The dispersion of Ta in the targets No. 3 and No. 4 can be calculated using the dispersion (%) formula which is expressly defined in the claims, namely,

dispersion (%) = {(maximum value - minimum value) / (maximum value + minimum value)} X 100.

Thus, the “dispersion (%)” as expressly defined in the claims is a measure of the fluctuation of the parameter in question, such as oxygen or Ta concentration.

As can be seen from Table A and the Appendix, the Ta content values measured vary

throughout the targets No. 3 and No. 4, with a measured maximum value of 1830 and 2540 ppm, respectively, and a measured minimum value of 784 and 2298 ppm, respectively. As can clearly be seen from the Ta content values of Table A and the expressly defined dispersion % formula, the dispersion % will not be 0, because the maximum and minimum values for the Ta content is not 0. Therefore, Ta dispersion, as that dispersion is defined in the claims, is not inherently 0. The same analysis would apply for oxygen dispersion.

Moreover, as an example that proves this lack of inherency, applicants point to the present specification, which provides numerous examples of a Nb sputtering target having Ta and oxygen with non-zero dispersion. Thus, it is inaccurate to suggest that, merely because a Nb sputtering target has inevitable Ta and oxygen impurities, such impurities would be uniformly dispersed within the target.

Ohhashi is silent regarding the dispersion of inevitable Ta and O impurities in his sputtering targets, and the dispersion range recited in the claims is not inherent in the Ohhashi targets. Ohhashi's sputtering target may contain amounts of Ta and/or oxygen that are above the upper limits of claims 1 and 18, and the dispersion values are incapable of being known based on the Ohhashi disclosure. Thus, the sputtering targets as claimed in claims 1 and 18, respectively, with the recited Ta and oxygen amounts and dispersion, are not described in Ohhashi. That is, claims, 1 and 18 do not read on any sputtering targets that are either identically described or disclosed in Ohhashi, nor upon any such targets that are taught or suggested by Ohhashi.

***Ohhashi fails to suggest the advantages of the claimed Ta and O impurity levels with the claimed dispersion levels***

Ohhashi fails to suggest the advantages of the invention as claimed, or to even recognize the parameters that are important in attaining these advantages. The inventors have determined important parameters in solving resistivity problems of Nb liner films for Al films. The present inventors have realized that merely decreasing the Ta or oxygen content alone does not decrease the resistivity of the entire Nb film with reproducibility. The

inventors have found that, in high purity Nb sputtering targets, the dispersion and content of Ta in the Nb target, and the dispersion and content of oxygen in the Nb target, are important parameters. These parameters are implemented in the sputtering targets of independent claims 1 and 18, which recite, respectively, the content and dispersion of Ta and content of oxygen, and the content and dispersion of oxygen which provide an improved Nb sputtering target. By suppressing the dispersion of Ta or oxygen in the Nb target, while at the same time decreasing the content of Ta or oxygen in the Nb target, it becomes possible to decrease the resistivity of the entire Nb wiring film, such as a film formed as a liner for an Al wiring film, when that film is formed using the sputtering target.

The beneficial effect of suppressing the dispersion of Ta or oxygen in the Nb target to within the levels recited in claims 1 and 18 is demonstrated in the present specification, as noted throughout the prosecution of this application. Ohhashi completely fails to recognize or teach this key relationship that is the basis for the present invention directed to a Nb sputtering target, and consequently the reference does not and cannot render the present invention "obvious".

In the Ohhashi disclosure, Nb is merely enumerated as one of various metal materials for sputtering targets. Ohhashi does not disclose any specific examples relating to a Nb target. Instead, Ohhashi discloses a high purity tungsten sputtering target (example 5) and a high purity titanium sputtering target (example 6). Thus, Ohhashi fails to teach or suggest any specific problems relating to impurities of Ta and/or O specifically in a Nb target, and in particular the Ta content and O content and the dispersions thereof, which are subject matter of claims 1 and 18.

The Office Action on pages 4-5, bridging paragraph, states as follows:

target No. 4 still has resistivity of interconnection higher than target No. 1 and 2. Moreover, target No. 7 has a dispersion % within the claimed range, but its resistivity of interconnection is much higher than targets No. 2 and 3. Moreover, as shown in instant Table 3 that O dispersion % can be as high as 80% which reads on from uniform to non-uniform O distribution. Applicants' argument as set forth in second full paragraph in page 10 of the said remarks is noted. But, Table 1 in instant specification merely shows that Ta less than 3000 ppm has a relatively lower resistivity of interconnection which is inherently possessed by the high purity Nb sputtering target of Ohhashi (See Rule 132 declaration filed April 12, 2004,

items 3-4). Moreover, Table 1 targets No. 3, 5 and 6 show that dispersion % has no effect with resistivity of interconnection (3 and 6 are outside the claimed “within 30%”).

Insofar as this statement in the Office Action suggests that the dispersion % of Ta and O impurities has no effect on the resistivity of the interconnections, or that the advantages of the combination of the claimed impurities level and dispersion of Ta and O in a Nb sputtering target are not demonstrated by the examples, applicants respectfully disagree.

Comparing target No. 4 (example) with target No. 3 (comparative example), although target No. 4 has a Ta content of 2540 ppm, which is higher than No. 3 containing a Ta content of 1830 ppm, the resistivity of No. 4 ( $3.8 \mu \Omega\text{cm}$ ) is  $0.1 \mu \Omega\text{cm}$  lower than that of target No. 3 ( $3.9 \mu \Omega\text{cm}$ ). This is because No. 4 has a dispersion of Ta content within specified range of 30% (5%) which is lower than that of No. 3 (40%), even though the Ta content of No. 4 is higher than that of No. 3. Thus, even when the Ta content in the target is relatively high (No. 4), by suppressing the dispersion of Ta content, it is possible to obtain a film having a resistivity equal or lower than that of a film formed with a Nb target having a smaller Ta content.

Moreover, with respect to target No. 5, although the dispersion of Ta content is within claimed 30%, its resistivity is  $10.5 \mu \Omega\text{cm}$ , much higher than  $4.0 \mu \Omega\text{cm}$ . This is because of the relatively larger Ta content exceeding the claimed 3000 ppm level. Thus, as can be seen from the examples, both a relatively lower Ta content as well as a relatively lower dispersion value are needed for lower resistivity.

In sum, in the Nb sputtering target containing Ta, which is difficult to separate from Nb, in order to decrease the effect of impurities, both (1) decreasing a Ta content to 3000 ppm or less, and (2) suppressing a dispersion of Ta content to within 30% are important. Thus, a Ta content of 3000 ppm or less can be tolerated as long as the dispersion is sufficiently low.

Analogous results are demonstrated in Table 3 for oxygen content and dispersion.

#### ***Claim 10***

Claim 10 is directed to a Nb sputtering target and recites parameters concerning the

grain diameter size of a Nb target that allows for suppressed occurrence of dust when sputtering. Claim 10, as amended, recites an average grain diameter of 100 $\mu$ m or less, a grain diameter in the range of 0.1 to 5 times an average grain diameter, and a dispersion of the grain size ratio of adjacent grains within 30%. The present inventors have found, based on investigation of the occurrence of dust particles generated from Nb targets, that the occurrence of giant dust particles can be effectively suppressed for the grain diameter parameters recited in claim 10.

Ohhashi discloses a sputtering target having uniform microstructure and crystal orientations with crystal grain sizes of no more than 350  $\mu$ m. Ohhashi, however, fails to teach or suggest the grain particle features recited in claim 10, or the advantages thereto in suppressing the occurrence of giant dust particles. Specifically, Ohhashi fails to disclose a Nb sputtering target where “each grain has a diameter in the range of 0.1 to 10 times the average grain diameter and a grain size ratio of adjacent grains is in the range 0.1 to 5”. Claim 10 is patentable over Ohhashi for at least this reason.

The Office Action asserts that the claimed grain size can be ranged from 10 to 1000  $\mu$ m. This statement, aside from being incorrect, misses the point that Ohhashi does not suggest an average grain size less than 100  $\mu$ m, or the advantages thereof in preventing dust. It is the average grain size as recited that provides advantages in reducing dust. Whether or not some of the larger grains (grains up to 1000  $\mu$ m) fall within the scope of the grains in the Ohhashi target is irrelevant. Neither does Ohhashi recognize that the average grain size is important in reducing dust, nor does Ohhashi disclose the specific average grain size recited in claim 10. Ohhashi merely discloses a crystal grain size of no more than 350  $\mu$ m.

The Examiner on page 4 of the Office Action states “arguendo the Nb sputtering target of Ohhashi contains Ta and/or O impurities but applicants fail to substantiate the dispersion of Ta and O in sputtering target of Ohhashi are non-uniform.” It is unclear from this statement what the Examiner intends as “non-uniform.” In any event, applicants, as discussed in detail above, have clearly provided that the dispersion %, as expressly defined in the claims, of inevitable impurities of Ta and O, such as may exist in the Ohhashi sputtering target, do not inherently have a dispersion % of 0 as suggested in the Office Action.

Moreover, Ohhashi does not suggest a dispersion % of inevitable impurities of Ta and O in a Nb sputtering target in the claimed range of claims 1 and 18.

The APA also fails to suggest the parameters as recited in claims 1, 10 and 18, and thus fails to cure the deficiencies of Ohhashi.

For at least the reasons given above, applicants respectfully submit that claims 1, 10 and 18 are patentable over Ohhashi and the APA. Independent claims 24 and 25 include the same Ta and oxygen parameter limitations of claims 1 and 18, respectively, and are thus patentable for at least those reasons. All dependent claims depend from one of claims 1, 10, and 18, and are patentable for at least the same reasons, as well as for further patentable features recited therein.

In view of the foregoing amendment and remarks, applicants respectfully reconsider the rejections of claims.

Applicant believes that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.



The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Respectfully submitted,

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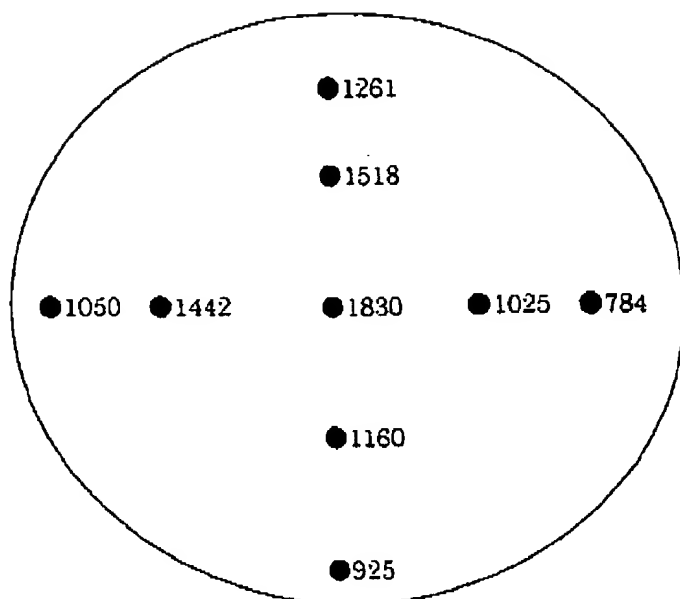


# APPENDIX



Target No. 3-

Ta content : 1830 ppm



Max. 1830 ppm, Min. 784 ppm

Dispersion % =  $\frac{(1830 - 784)}{(1830 + 784)} \times 100 = 40\%$ .



Target No. 4: Ta content: 2540 ppm



Max. 2540 ppm, Min. 2298 ppm

Dispersion % =  $\frac{(2540 - 2298)}{(2540 + 2298)} \times 100 = 5\%$ .